DATA RECORDING AND REPRODUCING APPARATUS, METHOD FOR RECORDING AND REPRODUCING VIDEO DATA, DISK DRIVE UNIT, AND CONTROL UNIT OF DATA RECORDING AND REPRODUCING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an apparatus and method for recording and reproducing data, which can be applied to a disk drive apparatus, and more particularly to a technology capable of recording video data while reproducing the same or other video data.

Background of the Invention

A magnetic tape is a popular recording medium for recording video data such as a TV program and a video cassette recorder (hereinafter referred to as VCR) which records video data onto the magnetic tape has spread very widely. The VCR is used not only to record TV programs but also to replay a video tape on which movies or other programs (hereinafter sometimes referred to as programs including TV programs).

The above described VCRs have the following problems and demands. First, when a plurality of programs are recorded on one video tape, a considerable amount of time is spent for a fast-forward or rewind to search a heading of a program to be reproduced. This is because the magnetic tape is a recording medium which is not suitable for random-accessing. Further, some viewers may want to record a TV program while watching this TV program from a desired point of time, or to record a TV program while

watching another TV program previously recorded. Although such desires mean that the viewers want to have a video recorder having a simultaneous recording and reproducing function, conventional VCRs have no such function.

An example of a digital video unit which would be effective for the above described problems is disclosed in Japanese Laid-Open Patent Application No. Hei 11-504175. This digital video unit include a digital video tape recorder and a hard disk drive. In this digital video unit, data is once recorded on a hard disk at the time of data recording, and then the data is transferred and copied to a digital video tape. When the data is to be reproduced, the data recorded on the digital video tape is once recorded on the hard disk, and then transferred to a display. According to the description of Japanese Laid-Open Patent Application No. Hei 11-504175, the random-accessible hard disk is used to realize quick reproducing from any point of a recorded program, and it is possible to reproduce a program recorded on the digital video tape while recording a different program. Accordingly, the digital video unit disclosed in Japanese Laid-Open Patent Application No. Hei 11-504175 may be effective for satisfying the demands of the viewers.

However, the above digital video unit requires two facilities, i.e. a recording and reproducing apparatus for digital video tapes, and a hard disk drive, which results in high cost. Although the digital video unit is functionally superior to analog VCRs widely used, the analog VCR is inexpensive and, therefore, the high cost

of the digital video unit obstructs its spread. Consequently, there is a need for an apparatus which is random-accessible and capable of performing simultaneous recording and reproducing with a single recording medium.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a data recording and reproducing apparatus which is random-accessible and capable of performing simultaneous recording and reproducing with a single recording medium, and a method therefor.

Another object of the present invention is to provide a disk drive unit suitable for such data recording and reproducing.

From a viewpoint of random-accessing, a hard disk drive is desirable as a recording device for achieving the objects of the present invention. However, owing to that the current hard disk drive shares data input and output paths and has only one magnetic head assembly for reading and writing data, either reading or writing can be done exclusively. This means that the current hard disk drive cannot perform simultaneous recording and reproducing. This is also true for other random-accessible recording devices such as digital video disks (DVDs). Accordingly, in the present invention, simultaneous recording and reproducing is achieved by separately providing data input and output paths which were shared in the conventional random-accessible recording devices, providing input and output buffers, respectively, for the input and output paths separately provided, and performing operations as described later.

Specifically, a data recording and reproducing apparatus of the present invention comprises a

random-accessible recording device for storing data; an input path for transferring input data to the recording device; an input buffer disposed on the input path for temporarily storing the input data; an output path for transferring output data stored in the recording device; an output buffer for temporarily storing the output data transferred through the output path; and a controller for simultaneously performing storing of the input data into the input buffer and transferring of the output data from the output buffer, in parallel with writing from the input buffer to the recording device or reading from the recording device to the output buffer.

Although the data recording and reproducing apparatus of the present invention achieves simultaneous recording and reproducing, this does not mean that the recording device can be read and written simultaneously. As a matter of course, if data can be read from and written to the recording device simultaneously, the simultaneous recording and reproducing can be performed. However, a hard disk drive which has only one magnetic head assembly cannot perform the simultaneous reading and writing. For example, although the current hard disk drive can reproduce a program fragmentarily while recording another program fragmentarily, this does not make sense for the normal recording and reproducing. Accordingly, the simultaneous recording and reproducing in the present invention does not mean such fragmentary ones but continuous and simultaneous recording and reproducing of a program or programs. If a plurality of magnetic head assemblies could be provided in the hard disk drive, it might be possible to perform simultaneous

reading and writing which would, however, result in a complex structure and higher cost. Therefore, the present invention achieves simultaneous recording and reproducing by utilizing buffers for temporarily storing data even if the recording device per se cannot perform simultaneous reading and writing. Note that the recording device (e.g. hard disk drive) in the data recording and reproducing apparatus of the present invention stores data, and is different from a hard disk drive disclosed in Japanese Patent Laid-Open No. Hei 11-504175, which is used as a buffer.

In the data recording and reproducing apparatus of the present invention, the input and output buffers may be the ones having a First in First out (hereinafter referred to as FiFo) function each of which desirably has two memory areas so that each buffer functions as a double buffer. Assuming that t_1 is a time required for writing data into the recording device the amount of which is sufficient to fill the first or second memory area of the input buffer, T_1 is a time required for filling the first or second memory area of the input buffer with data, t_2 is a time required for reading out data from the recording device the amount of which is sufficient to fill the first or second memory area of the output buffer, and T_2 is a time required for outputting all of the data filled in the first or second memory area of the output buffer, if $t_1 + t_2 < T_1$ and $t_1 + t_2 < T_2$ are satisfied, the simultaneous recording and reproducing can be done.

Furthermore, in the data recording and reproducing

apparatus of the present invention, a path used for command input and status output (hereinafter referred to as a command input/status output path) can be connected thereto. This command input/status output path is provided separately from the input path and the output path. Therefore, the command input or status output does not interrupt the data input or data output. In other words, it is possible to ensure the simultaneous recording and reproducing of continuous video data.

The data recording and reproducing apparatus of the present invention uses a random-accessible recording device such as a hard disk, and provides respectively data input and output buffers on input and output paths which are provided independently from each other, thus enabling the simultaneous recording and reproducing which continuously records video data onto a recording medium while reproducing the video data continuously. A method of the simultaneous recording and reproducing will be described below.

The method of the simultaneous recording and reproducing premises that a path for recording video data and a path for reproducing the video data exist independently from each other. The reason of this is as follows. If a common or shared path is used for recording and reproducing video data, the path cannot transfer video data to be reproduced while the path is being used for recording video data, or the path cannot transfer video data to be recorded while the path is being used for reproducing video data. Accordingly, this makes it impossible to perform the simultaneous recording and

reproducing. In the present invention, the input buffer and the output buffer are respectively provided on the separate input and output paths.

With the above premise, the method of the present invention comprises the steps of storing external video data into an input buffer, recording the video data stored in the input buffer to a recording device, reading the video data recorded in the recording device to an output buffer, and transferring the video data read out to the output buffer to the outside, the last step being executed simultaneously with the storing step.

It is desirable that each of the input buffer and the output buffer has two separate memory areas as described above. Thus, the present invention has made it possible to continuously record video data while continuously reproducing video data by utilizing the input and output buffers and by controlling the reading and writing of the video data. In the method of recording and reproducing video data according to the present invention, the video data continuously reproduced and the video data continuously recorded may be the same program, or they may be different programs.

The data recording and reproducing apparatus of the present invention can be provided as a disk drive unit. That is, according to the present invention, a disk drive unit is provided, which comprises a hard disk for storing data; an input path for transferring input data to the hard disk; an output path for transferring the data stored in said hard disk, the output path being separate

from the input path; and a file system disposed between the input and output paths and the recording device for managing the data stored in the hard disk. Since this disk drive unit is provided with the file system for managing the data stored in the hard disk, reading data from and writing data to the hard disk which are required for the simultaneous recording and reproducing can be performed quickly.

In the above disk drive unit, an input buffer is disposed on the input path, an output buffer is disposed on the output path, a controller for controlling the input buffer and the output buffer is provided between the input and output buffers and the hard disk, and the file system is built in the controller, to thereby improve the function of the disk drive unit.

Additionally, the data recording and reproducing apparatus of the present invention can be provided in a form in which the random-accessible recording device (e.g. hard disk), the input and output buffers and the controller are integrated, or can be provided in a unified form excluding the recording device. In other words, the present invention provides a control unit for a data recording and reproducing apparatus, which comprises an input buffer for temporarily storing data to be stored in a random-accessible recording device; an output buffer for temporarily storing data stored in the recording device upon transferring the data; and a controller which controls storing data into and outputting data from the input buffer and the output buffer and has a file system function for managing the

data stored in the recording device.

The data recording and reproducing apparatus of the present invention can be applied to a digital video recorder system for TV broadcast. In the case where the TV broadcast is analog, a tuner for receiving broadcast waves, means for digitizing analog video data received by the tuner and for compressing the digital video data, and means for expanding and converting to an analog form the data transferred from the data recording and reproducing apparatus of the present invention should be provided. In the case where the TV broadcast is digital, the compressing means is not required because compressed digital video signals are received.

BRIEF DESCRIPTIONS OF THE DRAWINGS

Figure 1 depicts a block diagram showing a data recording and reproducing apparatus according to an embodiment of the present invention.

Figure 2 depicts a diagram showing a configuration of a controller **14** incorporated in a hard disk drive **10** according to the embodiment of the present invention.

Figure 3 depicts a timing chart for explaining regular states of reading and writing processes.

Figure 4 depicts a timing chart of the reading and writing processes in the case where the writing process precedes the reading process.

Figure 5 depicts a timing chart of the reading and writing processes in the case where the reading process precedes the writing process.

Figure 6 depicts a timing chart in the case where the writing process is terminated from the regular states of the reading and writing processes.

Figure 7 depicts a timing chart in the case where the reading process is terminated from the regular states of the reading and writing processes.

Figure 8 depicts a control flow chart of the controller **14**.

Figure 9 depicts a flow chart for explaining the writing process.

Figure 10 depicts a flow chart for explaining the reading process.

Figure 11 depicts a diagram showing a list of commands supplied to the controller **14** from a command input/status output path **13**.

Figure 12 depicts a block diagram showing a digital video recorder system to which the present invention can be applied.

PREFERRED EMBODIMENTS OF THE INVENTION

Embodiments of the present invention will be described with reference to the accompanying drawings.

Figure 1 is a block diagram showing a data recording and reproducing apparatus **10** according to an embodiment of the present invention. **Figure 2** illustrates details of a controller **14** thereof.

The data recording and reproducing apparatus **10** of this embodiment is an example applied to a hard disk drive. The hard disk drive **10** is composed of a magnetic disk **15**, an input buffer **12** positioned on an input path **11**, an output buffer 16 positioned on an output path **17**, and a controller **14** positioned between the input and output buffers **12**, **16** and the magnetic disk **15** by which a unit is constituted. As described above, however, the hard disk drive **10** of, for example, an IDE type may be a unit corresponding to the magnetic disk **15**. In that case, the input buffer **12**, the output buffer **16** and the controller **14** constitute a control unit for the hard disk drive **10**.

Input data transferred over the input path **11** is temporarily stored in the input buffer **12**, and then transferred to and stored in the magnetic disk **15** under the control of the controller **14**.

An example for implementing the input buffer **12** is next described. A data storage or memory area of the

input buffer **12** is divided into two pages. At an initial stage, the input buffer begins to store the input data which is video data from a start address of a first page (hereinafter referred to as Page 0). When Page 0 is filled with the data, it is notified to the controller **14**. When the controller **14** requests to deliver the data filled in Page 0, the input buffer **12** passes quickly the requested data to the controller **14**. At the same time, the video data continuously transferred is stored in the input buffer **12** beginning from a start address of a second page (hereinafter referred to as Page 1). When Page 1 is filled with the data, it is notified to the controller **14**. When the controller **14** requests to deliver the data filled in Page 1, the input buffer **12** passes quickly the requested data to the controller **14**. At the same time, the input buffer **12** stores the video data transferred thereto beginning from the start address of Page 0. These operations are repeated thereafter.

The operational procedure of the input buffer **12** described above can be realized by using hardware, and also by using software installed in the controller **14**. With regard to the implementation of the input buffer **12**, there exists other means for implementing equivalent functions such as the one using a circular buffer. Any input buffer using such implementing means is within the scope of the present invention. The above is also true for the output buffer **16** described below.

Next, the output buffer **16** will be described. The output buffer **16** stores temporarily output data which is

video data from the magnetic disk **15**, and transfers the output data through the output path **17**. Basically, the output buffer **16** should have an FiFo buffer function as in the case of the input buffer **12**. When the data temporarily stored in the input buffer **12** is to be output under the control of the controller **14**, the output buffer 16 stores temporarily the output data or video data from the input buffer **12**.

An example for implementing the output buffer **16** is next described. A data storage or memory area of the output buffer **16** is divided into two pages. At an initial stage, the output buffer **16** begins to store from a start address of Page 0 output data or video data transferred from the magnetic disk **15** under the control of the controller **14**. When Page 0 is filled with the output data, the output buffer 16 begins to transfer the output data to the output path **17** beginning from the start address of Page 0 and notifies the controller **14** of completion of the receipt of the output data. At the same time, the output buffer **16** sequentially stores the video data continuously transferred, beginning from the start address of Page 1. When Page 1 is filled with the video data, the video data filled in Page 1 is transferred onto the output path **17** after all of the video data stored in Page 0 is transferred onto the output path **17**. Concurrently, the output buffer **17** notifies the controller **14** that it is ready for receiving output data, and then the output buffer **17** stores sequentially video data next transferred beginning from the start address of Page 0. Thereafter, each time when the transfer of video

data to the output path **17** is completed for each page, the receipt and transfer of video data are repeated by switching Page 0 and Page 1.

The following conditions must be satisfied as a premise for the implementation examples of the above described input and output buffers **12** and **16**. Specifically, assuming that t_1 is a time required for writing video data into the magnetic disk **15** the amount of which is sufficient to fill Page 0 (or Page 1) of the input buffer **12**, T_1 is a time required for filling Page 0 (or Page 1) of the input buffer **12** with video data, t_2 is a time required for reading out video data from the magnetic disk **15** the amount of which is sufficient to fill Page 0 (or Page 1) of the output buffer **16**, and T_2 is a time required for completing the transfer of all video data filled in Page 0 (or Page 1) of the output buffer **16** onto the output path **17**, then $t_1 + t_2 > T_1$ and $t_1 + t_2 > T_2$ must be satisfied. Specifically, $t_1 + t_2 > T_1$ means that writing a page of data from the input buffer **12** onto the magnetic disk **15** and reading a page of data from the magnetic disk **15** into the output buffer **16** are completed before Page 0 (or Page 1) of the input buffer **12** is filled with the video data. Similarly, $t_1 + t_2 > T_2$ means that writing a page of data from the input buffer **12** onto the magnetic disk **15** and reading a page of data from the magnetic disk **15** into the output buffer **16** are completed before the transfer of the video data filled in Page 0 (or Page 1) of the output buffer **16** is completed.

The command input/status output path **13** is an

external communication path for transferring commands from the outside to the controller **14** and for supplying status and data management information from the controller **14** to outside.

Next, the functions of the controller **14** will be described.

As shown in **Figure 2**, the controller **14** is provided with a command reception/status transmission function, a file system function, an input management function, an output management function and a disk management function. The controller **14** having the above-described functions controls the magnetic disk **15**, the input buffer **12** and the output buffer **16** in response to the commands supplied from the outside through the command input/status output path **13**. The controller **14** manages data stored in the magnetic disk **15** by its file system function. Specifically, the data management of the controller **14** includes naming and storage area allocation for each data segment to be stored in the magnetic disk **15**, deletion of stored data and release of its storage area, and inhibition of file deletion.

Typical commands supplied to the controller **14** through the command input/status output path **13** are illustrated in the diagram of **Figure 11**. Some concrete operations performed in response to the commands are described below.

In response to the command "Read" supplied from the

outside, the controller **14** determines by the file system function where in the magnetic disk **15** a specified file is stored physically, reads the file from the magnetic disk **15**, and controls an output system comprising the output buffer **16** and the output path **17** to consecutively transfer the file.

In response to the command "Write" supplied from the outside, the controller **14** reserves a write area in the magnetic disk **15** by the file system function, and controls an input system comprising the input buffer **12** and the input path **11** to sequentially store input data consecutively transferred through the input system into the write area of the magnetic disk **15**.

In response to the command "Directory" supplied from the outside, the controller **14** creates a list of data including file name, size and date/time of storage which are stored in the magnetic disk **15**, and transfers them to the outside as status data.

Next, some examples of reading and writing processes for performing the simultaneous recording and reproducing will be concretely described based on timing charts shown in **Figures 3** to **7**. Described below are five cases which are a regular state of the reading and writing processes (**Figure 3**), a second case where the writing process precedes the reading process (**Figure 4**), a third case where the reading process precedes the writing process (**Figure 5**), a fourth case where the writing process is terminated from the regular state (**Figure 6**), and a fifth

case where the reading process is terminated from the regular state (**Figure 7**).

Figure 3 is a timing chart where the reading and writing processes are in a regular state. In **Figure 3**, video data R to be read comprises R_1, R_2, R_3, R_4,...., and video data W to be written comprises W_1, W_2, W_3, W_4,....

The reading process is first described. In **Figure 3**, a reading request is issued from the controller **14** to the magnetic disk **15** in which the video data R is stored. The video data R_1 is temporarily stored in Page 0 of the output buffer **16**. When a preceding output from Page 1 of the output buffer **16** to the output path **17** is completed, the video data R_1 in Page 0 of the output buffer **16** is begun to be output to the output path **17**, and the video data R_2 is read out from the magnetic disk **15** and temporarily stored in Page 1 of the output buffer **16**. When the video data R_1 is completely output from Page 0 to the output path **17**, the video data R_2 in Page 1 is begun to be output to the output path **17**, and then the video data R_3 is read out from the magnetic disk **15** and temporarily stored in Page 0 of the output buffer **16**. After the video data R_2 is completely output, the video data R_3 is output to the output path **17**. These operations are repeated for the video data R_4 and the video data subsequent thereto. In this manner, the video data R recorded in the magnetic disk **15** can be continuously reproduced without omission by dividing the video data R into predetermined units such as R_1, R_2, R_3, R_4,...., and sequentially reading them.

Next, the writing process is described. When the video data W_1 is stored in Page 1 of the input buffer **12** and Page 1 is filled with the video data W_1, the video data W_1 is written to the magnetic disk **15**. At the same time, the video data W_2 continuously transferred is temporarily stored in Page 0 of the input buffer **12**. When Page 0 of the input buffer **12** is filled the video data W_2, the video data W_2 is stored in the magnetic disk **15**. These operations are repeated for the video data W_3 and the video data subsequent thereto, and thus the video data W constituting a program can be recorded continuously without omission by dividing the video data W into predetermined units such as W_1, W_2, W_3, W_4,...., and sequentially recording them on the magnetic disk **15**.

Next, the mixed reading and writing processes are described. While the video data R_1 read out from the magnetic disk **15** and temporarily stored in Page 0 of the output buffer **16** is being output and the input data is being stored in Page 0 of the input buffer **12**, the video data W_1 stored in Page 1 of the input buffer **12** is written to the magnetic disk **15**, and the video data R_2 is read out from the magnetic disk **15** and temporarily stored in Page 1 of the output buffer **16**. Subsequently, while the video data R_2 temporarily stored in Page 1 of the output buffer **16** is being output therefrom and the input data is being stored in Page 1 of the input buffer **12**, the video data W_2 stored in Page 0 of the input buffer **12** is written to the magnetic disk **15**, and the video data R_3 is read out from the magnetic disk **15** and temporarily stored in Page 1 of the output buffer **16**. In this manner,

during outputting of video data from one page of the output buffer **16** and during storing of video data into one page of the input buffer, the other page of each of the input and output buffers **12** and **16** is used for reading from and writing to the magnetic disk **15** in which the reading and writing are controlled so as not to overlap with each other so that the video data W is recorded while the video data R is continuously reproduced. Note that the reading and writing may not be performed alternately. This can be understood from the order of reading R_3 and R_4 from the magnetic disk **15** and writing W_3 to the magnetic disk **15**, as shown in **Figure 3**. Namely, while the video data R_3 in the Page 0 area of the output buffer **16** is being output, reading of the video data R_4 should be completed. With respect to the writing, on the other hand, while the video data W_4 is being temporarily stored in the Page 0 area of the input buffer **12**, writing of the video data W_3 should be completed. If the reading and writing do not overlap with each other, the simultaneous recording and reproducing can be done. Additionally, page switching of the input buffer **12** and the output buffer **16** may not performed simultaneously. Assuming that t_1 is a time required for writing the video data onto the magnetic disk **15** the amount of which is sufficient to fill Page 0 (or Page 1) of the input buffer **12**, T_1 is a time required for filling Page 0 (or Page 1) of the input buffer **12** with the video data, t_2 is a time required for reading out the video data from the magnetic disk **15** the amount of which is sufficient to fill Page 0 (or Page 1) of the output buffer **16**, and T_2 is a time required for completing transfer of all of the video data

filled in Page 0 (or Page 1) of the output buffer **16** to the output path **17**, then $t_1 + t_2 > T_1$ and $t_1 + t_2 > T_2$ should be always satisfied. Specifically, $t_1 + t_2 > T_1$ means that writing a page of data from the input buffer **12** onto the magnetic disk **15** and reading a page of data from the magnetic disk **15** to the output buffer **16** are completed before Page 0 (or Page 1) of the input buffer **12** is filled with the video data. Also, $t_1 + t_2 > T_2$ means that writing a page of data from the input buffer **12** onto the magnetic disk **15** and reading a page of data from the magnetic disk **15** to the output buffer **16** are completed before transfer of the video data filled in Page 0 (or Page 1) of the output buffer **16** is completed.

Next, the case in which the writing process precedes the reading process will be described with reference to **Figure 4**.

When the writing process is in progress, the reading process starts after the current writing to the magnetic disk **15** is completed and before a next writing request is issued so that the reading and writing of the magnetic disk **15** do not overlap with each other. Specifically, R_1 of the video data R stored in the magnetic disk **15** is read out and temporarily stored in Page 0 of the output buffer **16** after the video data W_n stored in Page 0 of the input buffer **12** is completely written on the magnetic disk **15** and before the video data W_{n+1} stored in Page 1 of the input buffer **12** is begun to be written onto the magnetic disk **15**.

There may be no output before starting the reading process. However, dummy data such as a test pattern or logo may be output by supplying predefined data from the controller **14** to the output buffer **16**.

Next, the case where the reading process precedes the writing process will be described with reference to **Figure 5**.

When the reading process is in progress, the writing process to the magnetic disk **15** starts after the current reading of the magnetic disk **15** is completed and before a next reading request is issued so that the reading and writing of the magnetic disk **15** do not overlap with each other. Specifically, the writing of the video data W_n stored in Page 0 of the input buffer **12** to the magnetic disk **15** starts after R_n in the video data R written to the magnetic disk **15** is completely read out and before the reading of the next video data R_{n+1} starts.

Next, the case where the writing process is terminated will be described with reference to **Figure 6**.

Termination of writing may occur at any point of time. Accordingly, the end of written data scarcely aligns with the end of Page 0 (or Page 1) of the input buffer **12**. It is, therefore, necessary to do padding or to add dummy data to fill a unit of writing of the magnetic disk **15** (sector size, for example, 512 bytes, 4096 bytes, etc.) or Page 0 (or Page 1) of the input buffer **12** in addition to the video data last written. The arrow shown by the video data W_{end} in **Figure 6** indicates

that writing to the magnetic disk **15** has been performed after the padding is done. The amount of dummy data to be added is adjusted to either a unit of writing of the magnetic disk **15** or a size of Page 0 (or Page 1) of the input buffer **12** depending on the implementation of the file system of the controller **14**.

Finally, the case where the reading process is terminated will be described with reference to **Figure 7**.

It is seen that the end of read data scarcely aligns with the end of Page 0 (or Page 1) of the output buffer **12**. Accordingly, as shown in **Figure 7**, after the video data W_n is written from Page 0 of the input buffer **12** to the magnetic disk **15** and then the last video data R_{end} in the video data R stored in the magnetic disk **15** is transferred to Page 0 of the output buffer **16**, there may be no output or dummy data such as a test pattern or logo may be output by supplying predefined data from the controller **14** to the output buffer **16**.

Figures 8, **9** and **10** are a control flow chart of the controller **14**, a flow chart for explaining the write process and a flow chart for explaining the read process, respectively. Details of these flow charts will be described below.

First, as shown in **Figure 8**, in step **101** (shown as **S101**, the same rule applies to the rest), the controller **14** decides whether the control command is an initialize command. If the control command is the initialize

command, the controller 14 initializes the magnetic disk **15**. If the control command is not the initialize command, the controller **14** decides in step **102** whether the control command is a file create command. If the control command is the file create command, the controller **14** creates a new file in the magnetic disk **15**. If the control command is not the file create command, the procedure proceeds to step **103**, and the controller **14** decides whether the control command is a file delete command. If the control command is the file delete command, the controller **14** deletes a specified file. If the control command is not the file delete command, the controller **14** decides in step **104** whether the controller command is a file read command. If the control command is the file read command, the controller **14** start a read process. If the control command is not the read command, the controller **14** decides in step **105** whether the control command is a file write command. If the control command is the file write command, the controller **14** start a write process. If the control command is not the file write command, the controller **14** decides in step **106** whether the control command is a close command. If the control command is the close command, the controller **14** terminates reading or writing of a specified file by sending out a termination command to the specified process. In the case of the writing, data remaining in the input buffer **12** is stored in the magnetic disk **15**. If the control command is not the close command, the controller **14** decides in step **107** whether the control command is a directory command. If the control command is the directory command, the controller **14** returns, as a status, directory information

such as file name, file size, recording date/time and additional information.

In **Figure 9**, the writing process starts and, in step **201**, acquires a writing area on the magnetic disk **15** by a file system incorporated in the controller **14**. Then, input of video data to the input buffer **12** is started in step **202**. After the input is started, the controller **14** waits for a writing request for the magnetic disk **15** or a writing termination command in step **203**, and decides in step **204** whether the command received is the writing termination command. If the command is not the writing termination command, the controller **14** confirms in step **205** whether the magnetic disk **15** is processing a request, that is, whether it is at a point between the reading request and the termination of the reading. If the magnetic disk **15** is not processing the request, the controller **14** writes to the magnetic disk **15** in step **206**. If the magnetic disk is processing the request, the controller **14** confirms again whether the magnetic disk **15** is processing the request. On the other hand, if the command is decided to be the writing termination command in step **204**, the controller **14** stops inputting the video data to the input buffer and adds dummy data for padding in step **207**. Next, in step **208**, the controller **14** confirms whether the magnetic disk **15** is processing the request. If the magnetic disk **15** is not processing the request, the controller **14** writes to the magnetic disk **15** in step **209**. Thereafter, a writing completion processing is performed by the file system in step **210**, thus terminating a series of writing processings.

In **Figure 10**, the reading process starts and, in step **301**, acquires information concerning a file to be read out in the magnetic disk **15** by the file system incorporated in the controller **14**. Next, in step **302**, the controller **14** confirms whether the magnetic disk **15** is processing a request, that is, whether it is at a point between the writing processing request and the termination of the writing. If the magnetic disk **15** is not processing the request, the controller **14** reads from the magnetic disk **15** based on the above described file information in step **303**, and outputs the read data from the output buffer **16** in step **304**. Next, the controller **14** confirms in step **305** whether the magnetic disk **15** is processing the request. If the magnetic disk **15** is processing the request, the controller **14** waits. If the magnetic disk **15** is not processing the request, the controller **14** reads from the magnetic disk **15** in step **306**. Thereafter, in step **307**, the controller **14** waits for a reading request, a reading termination command or a reading completion notification. Next, in step **308**, the controller **14** confirms whether the command is the reading termination command. If the command is not the reading termination command, the process returns to step **305**. If the command is the reading termination command, the controller **14** stops outputting the video data from the output buffer **16** in step **309**. Thereafter, the controller **14** performs the reading completion process by the file system in step **310**, thus terminating a series of the reading processings.

Next, an example in which the hard disk drive **10** is

applied to a digital video recorder system will be described with reference to **Figure 12**. Since the hard disk drive **10** has already been described in detail, components other than the hard disk drive **10** will be described below.

As shown in **Figure 12**, a digital video recorder system **1** is constituted by a tuner **2** and a MPEG (Moving Picture Experts Group) encoder **3** which are provided on the input path **11**, a video controller **4** and a MPEG (Moving Picture Experts Group) decoder **5** which are provided on the output path **17**, a hard disk drive **10**, a modem **6**, a main controller **7**, a television receiver **8** and a remote controller **9**.

The tuner **2** receives, for example, TV broadcast (program). The TV program is either analog broadcast or digital broadcast. In this embodiment, the analog broadcast is described although the present invention can also be applied to the digital broadcast. In the digital broadcast, the MPEG encoder **3** is not required because compressed signals are received.

The MPEG encoder **3** has a function to digitize analog signals and compress them. The MPEG decoder **5** has a function to expand the compressed video data, and the video controller **4** has a function of digital to analog conversion in addition to the conventional video controller function.

The main controller **7** controls the tuner **2**, the MPEG

encoder **3**, the video controller **4**, the MPEG decoder **5** and the controller **14** of the hard disk drive **10**. The modem **6** is connected to the main controller **7**. If an electronic program guide is provided, for example, on Internet, a viewer can automatically record his/her desired program via the modem **6** based on the electronic program guide. The main controller **7** executes predetermined controls in response to the operation of the remote controller **9**.

The tuner **2** receives, for example, TV broadcast. In this embodiment, a TV program, that is, video data containing audio is assumed to be composed of analog signals as described above. When the viewer operates the remote controller **9** to record the TV program, the following recording process is executed. Specifically, the MPEG encoder **3** digitizes the analog signals and compresses them. The digitized video data is transferred over the input path **11**, and stored in the input buffer **12** temporarily. The input data temporarily stored is transferred to and stored in the magnetic disk **15** under the control of the controller **14**. The TV program is thus recorded. The specific details of the temporary storage of the input data in the input buffer **12**, transfer of the input data to the magnetic disk **15** and storing of the input data in the magnetic disk **15** are described above.

When the viewer operates the remote controller **9** to reproduce a TV or other program recorded on the magnetic disk **15**, the video data recorded on the magnetic disk **15** is output to the output buffer **16** under the control of the main controller **7** and the controller **14** of the hard

disk drive **10**. The video data temporarily stored in the output buffer **16** is expanded by the MPEG decoder **5** and transferred to the video controller **4**. The video data is converted to an analog form in the video controller **4**, and thereafter reproduced on the screen of the television receiver **8** under the control of the video controller **4**. The specific details of transfer of the video data from the magnetic disk **15** to the output buffer **16**, temporary storing of the video data in the output buffer **16**, and output of the video data from the output buffer **16** are described above.

Since the above digital video recorder system **1** is provided with the hard disk drive **10** which is capable of performing simultaneous recording and reproducing, a TV program can be recorded while the recorded program is reproduced from any point. Also, a TV program can be recorded while a different program recorded on the magnetic disk **15** is reproduced.

As described above, according to the present invention, a data recording and reproducing apparatus which is capable of performing simultaneous recording and reproducing using a random-accessible recording device such as magnetic disk is provided. Also, the present invention provides a method for recording and reproducing video data which is suitable for such data recording and reproducing apparatus. Therefore, a program which a viewer desires to reproduce can be found in a short time, and the present invention satisfies viewer's needs that they want to record a TV program while watching the

recorded program from any point, or that they want record a TV program while watching a different TV program previously recorded.